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BER Analysis of Wavelet Based OFDM Using Different Modulation Techniques

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Abstract: ***In this paper, we propose a new scheme for data transmission in Long Term Evolution (LTE) methods based on Orthogonal Frequency Division Multiplexing (OFDM). In OFDM scheme we compare Discrete Fourier Transform (DFT) based OFDM with wavelet based technique. In this method, DWT-COIFLET (Discrete wavelet transform) is used for wavelet decomposition, we compare COIFLET wavelet with traditional wavelet decomposition techniques like Daubechies2 and haar and also we prove that DWT-COIFLET wavelet will yield better performance. The use of maximum Ratio combining equalizer for LTE based MIMO scheme decreases MSE ultimately BER will be reduced. We compare our wavelet based LTE scheme with state-of-art criteria like DFT based LTE scheme, traditional wavelet based LTE (haar and Daubechies2) and we prove that our methodology will yield better results compare to previous methodology based on Bit error rate calculation in 64-QAM modulation scheme.***

Keywords: LTE; OFDM, DFT, Wavelet, BER.

1. Introduction

OFDM is one of the key technologies which enable non-line of sight wireless [10] services making it possible to extend wireless access method over wide-areas. It is a deviation of the Frequency Division Multiplexing scheme in which the frequency channel is divided into multiple smaller sub-channels. Sub-channelization in FDM requires provisioning of guard bands between two sub-channels to avoid interference between them. OFDM [4] divides the frequency bandwidth in narrow orthogonal sub-parts called sub-carriers. A sub-channel is the combination of a number of these sub-carriers. The sub-carriers comprise data carriers and pilot carriers along with a DC. The data carriers are used to transmit data and pilot carriers are used for sensing purpose. Subcarriers are usually modulated with usual modulation techniques such as Quadrature Amplitude Modulation or Phase Shift Keying. (PSK) .Every user is provided with a number of sub-channels, each of them is composed of a number of sub-carriers. Data of the user is carried parallel on each sub-carrier at a low rate. The combination of the parallel sub-carriers at the destination provide for the high data rates. Since the sub-carriers transmit data at a low rate and thus higher symbol time it is more durable to multipath effects, so this makes more suitable for wide-area non-line of Sight wireless access and also, the use of overlapping orthogonal sub-carriers without guard bands make it more capable than FDM scheme. OFDM resembles CDMA in that it is also a spread-spectrum expertise in which energy generated at a particular bandwidth is spread across a wider bandwidth making it more durable to intrusion and "jamming".

Multiple Input Multiple Output (MIMO) is one of the most popular Advanced Antenna Technologies which is used in LTE [5][6] and Ultra Mobile broadband(UMB). The attractive features of MIMO is it offers good throughput. The transmitter and receiver have multiple antennas in MIMO giving multiple flavors based on the number of antennas present on both sides. The input idea is that a transmitter sends multiple flows on multiple transmit antennas 9 of 15 and each transmitted flow goes through different paths to reach each receiver antenna. The different paths taken by the same flow to reach multiple receivers allow canceling errors using advanced signal processing techniques.

On the same frequency MIMO achieves spatial multiplexing to distinguish among different symbols. Thus MIMO helps in achieving higher spectral efficiency. The DWT-COIFLET OFDM has to satisfy the ortho-normal basis and for OFDM the perfect restoration properties to be considered. For different wavelet families the BER concert is compared with the conventional FFT-OFDM method for AWGN. The results show that the DWT-OFDM method operates at its finest concert with different wavelets. Results also show that DWT-OFDM is advanced as compared to FFT-OFDM [7] with regards to the bit error rate (BER) concert in AWGN channel.

2. Existing Method

The DFT-based channel evaluation technique has been derived to improve the concert of LS or MMSE channel evaluation by eliminating the effect of distortion outside the utmost channel delay. The estimate of channel gain at the k th subcarrier, obtained by moreover LS or MMSE channel estimation method. Taking the IDFT of the channel estimate, Application of DFT on LS, MMSE channel evaluation can improve the concert of estimators by eliminating the distortion effects. In this OFDM method, the period of the channel impulse response is usually less than the period of the cyclic prefix L. DFT-based algorithm uses this aspect to increase the concert of the MMSE and LS algorithms. It will transformed into the frequency channel evaluation into time channel evaluation using IDFT, considers the part which is superior than L as distortion, and then treats that part as zero in order to eliminate the impact of the distortion.

DFT-based [8] channel evaluation methods allow a declining of the distortion component owing to operations in the different domains, to achieve higher evaluation accuracy. In fact, after removing the unused subcarriers, the LS estimates are first converted into the time domain by the IDFT (inverse discrete Fourier transform) algorithm. A smoothing filter is then applied in the time domain assuming that the utmost multi-path delay is kept within the cyclic prefix (CP) of the symbol. Because of this consequence, the distortion power is compact in the time domain [1]. Lastly the DFT is applied to return to the frequency domain.

In a realistic context, only a subset of *M* subcarriers is modulated among the *N* due to the insertion of null subcarriers at the spectrum's extremities for RF mask requirements. The application of the smoothing filter in the time domain will lead to a loss of channel power when these non-modulated subcarriers are present at the border of the spectrum. That can be confirmed by calculating the time domain channel response. The time domain channel response of the *LS* estimated channel.

In OFDM methods, when null carriers are inserted at the spectrum extremities, the concert of the DFT based channel evaluation is degraded especially at the borders of the modulated subcarriers. This phenomenon is called the "border effect". This effect is also observed in MIMO context. In order to evaluate the DFT based channel evaluation, the mean square error (MSE) [12] concert for the different modulated subcarriers.

3. Proposed Method

Wavelet Transform is an significant mathematical function, because as a tool for multi resolution dissolution of continuous time signal by different times and frequencies. In wavelet transform, higher frequencies are sophisticated decided in time, as well as lesser frequencies are better decided in frequency. Happening this intellect, the signal remains reproduced through an orthogonal wavelet intention, in growth the transform is calculated alone changed parts of the time domain signal. The wavelet transform can be classified as two categories, continuous ripple transform and discrete ripple transform.

The Discrete Ripple Transform could be observed by way of sub-band coding. The signal is analyzed and it accepted over a filter bank succession. A sub-band coding method is defined as full-band source signal is spitted into distorted frequency bands as well as encrypt every band separately established on their spectrum energy. The sub-band coding methodology learning starts from the digital filter bank method; it can be defined as a set of filters with has distorted centre frequencies. Double channel filter bank is mostly used in growth the effective way to tool the discrete ripple transform. Generally, the filter bank plan has double steps which are used in signal transmission scheme.

The first step is named as analysis stage which agrees toward the decomposition procedure by using down sampling the signal samples remains condensed. Synthesis interval is the next step which agrees to the exclamation procedure in which the signal samples are improved by two (up sampling). The analysis interval involves of sub-band filter inspective by down sampler while the synthesis interval involves of sub-band filter up sampler positioned. The sub-band interval used through the channel filter exists perfect restoration. Consequently there are high pass filter as well as low pass filters at each stage, the interval analyses takes double output coachable also they are named as estimate coachable which contain the small frequency information of the signal then detail coachable which comprise the high frequency data of the signal. The analysis interval of the multi-level double channels impeccable restoration filter bank scheme is charity for formative the DWT coachable.

The procedure of restoration the basis signal as of the DWT coachable is so-called the inverse discrete Ripple transform (IDRT). Aimed at each level of restoration filter bank the calculation then details coachable are up sampled in growth to passed over low pass filter and high pass synthesis filter. Discrete Wavelet Transform [2] is designed as high presentation digital signal processing method for procedure in applying multicarrier modulation. The block diagram plan of multicarrier transceiver arithmetical method constructed on DWT. The method project include of an inverse discrete wave-let transform (IDWT) as modulator at the transmitter as well as a discrete ripple transform (DWT) as demodulator at the side of receiver.

The leading plus the vital adaptation among the conventional OFDM as well as DWT multicarrier scheme is the removal of the cyclic prefix blocks in the transmitter otherwise in the receiver parts. The assets of wavelets in growth to varieties it by way of a ethical outstanding for numerous applications identical separation in image, nuclear, biomedical, magnetic resonance imaging, music, fractals, turbulence, pure mathematics, data compression, computer graphics also animation, human vision, radar and an deep description for growth applications remained offered

There are several advantages of using COIFLET wavelets for wireless communication methods. The hardly any desirable features of wavelets are the following:

- Wavelet transform can generate subcarriers of different bandwidth and symbol span.
- The capability of wavelets to display the time frequency tiling in a manner that minimizes the channel disturbances minimizes the effect of distortion and intrusion on the signal.
- Wavelets give a new aspect, signal diversity which could be exploited in a cellular communication method, where adjacent cells can be designated different wavelets in order to minimize inter-cell intrusion.
- Wavelet-based algorithms have long been used for data compression. By compressing the data, a compact volume of data is transmitted so that the communication power needed for transmission is compact.
- Mitigation of Intrusion ISI and ICI*:* ISI (Inter symbol intrusion) and ICI (Inter Carrier Intrusion) are inclined by shape of the basic pulse. Time dispersion contributes intrusion due to multipath effect and frequency dispersion due to non-linear effects of radio channel. In wireless scenario the channel effects cannot be controlled. But the pulse shape can be alertly designed to have minimum distortion for a given delay spread. The wavelet transform [9] allows more flexibility in the design of the pulse shape. Many researchers proved that the wavelet based

multicarrier schemes are advanced in suppressing ICI and ISI as compared to the traditional Fourier based methods.

COIFLET Wavelets are small waveforms with a set oscillatory structure that is non-zero for a limited interval of time (or space). By using wavelet bases, wavelet filters are characterized [3]. These signal transmission techniques allow for significant increase in wireless technique without increase in bandwidth. DFT based OFDM is a Multi-Carrier Modulation (MCM) scheme where the sub carriers are orthogonal. The rectangular window used in its implementation creates high side lobes. Whereas, DWT-OFDM has longer basis functions and hence can offer higher degree of side lobe suppression. The transmitted signal *x*[k] is composed of modulated symbols successively, as the sum of M waveforms are constructed individually. The discrete domain representation can be done as follows:

$$\mathbf{X[k]}=\sum\sum_{s}\sum_{m=0}^{M-1}(\boldsymbol{aj},\boldsymbol{\emptyset m}[\boldsymbol{k}-\boldsymbol{sM}])$$

In DWT-OFDM, the discrete functions si(k) are the complex exponential basis functions. The transmitted symbol is built by performing inverse DWT while the forward DWT is used to retrieve the data symbol. The carrier waveforms are obtained by iteratively filtering the signal into high and low frequency components. The affiliation between the number of iterations J and the number of carrier waveforms M is given by M 2J. In literature survey hardly they concentrate on any wavelets that are renowned by many authors. Some distinctive characteristics of every wavelet make it more suitable for one application than other. While designing a method the alert consideration of different wavelet properties should be made with respect to the method necessities. The selection of wavelets is generally made on the following wavelet properties:

- **Support***:* Compact support is defined by the span (L) of the filter. Shorter filters have decreased computational complexity.
- **Orthogonality:** It is one of the most vital wavelet properties as it ensures perfect renovation. For communication purposes we absolutely require orthogonal wavelets.
- **Symmetry***:* Symmetrical wavelets have a feature that transform of the mirror of an image is the same to the mirror of the wavelet transform. None of the orthogonal wavelets except COIFLET wavelet is symmetric.
- **K-Regularity/Vanishing Moments:** *K*-regularity is also an significant measure for wavelets because it helps to reduce non-zero coachable in the high pass sub-bands and it is one of the easiest ways to resolve if a scaling function is fractal or not.

The same modulator is used in QPSK, however binary information in both I and Q channels, as described above. Each message has two levels i.e., ±V volt respectively. The amplitude of the output DSBSC does not vary for a non-band limited message. when the message changes polarization is interpreted as a 180^0 phase shift, given to the DSBSC. Thus the signal in each arm is said to be undergoing a phase shift keying, or 180^0 phase shift. Since there are two PSK signals mixed, in quadrature, the two-channel modulator gives rise to a quadrature phase shift keyed - QPSK signal.

16QAM as well as full-rate 16QAM and the criterion used for adapting the modem modes was based on the instantaneous channel delay spread and received signal to distortion ratio. For gradually varying channel quality of the uplink (UL) and downlink (DL) was rendered similar by utilizing short frame duration Time Division Duplex (TDD) and the utmost normalized delay spread simulated was 0:1.

A variable channel coding rate was then introduced by Matsuoka *et al.* in combination with adaptive modulation. In reference, wherever the transmitted burst incorporated an outer Reed Solomon code and an inner convolution code in order to achieve high-quality information transmission and coding rate can changed according to the prevalent channel quality using the same method, as in adaptive modulation in order to achieve a certain target BER concert.

A so-called channel margin was introduced in this contribution, which effectively increased the switching thresholds for the sake of preempting the effects of channel quality evaluation errors, although this inevitably compact the achievable BPS throughput. For domestic broadcast applications for example, 64 QAM and 256 QAM are frequently used in digital cable television and cable modem applications.

4. Results

By using QPSK modulation, BER performance can be compared using different wavelets and transforms in fig.1 and from the Fig.1 we can draw the statement that db2 gives best performance compared to haar and DFT. It is clear from the Fig. 2 and Fig. 3 that the BER performance of wavelet based OFDM is better than the DFT based OFDM. Fig. 2 shows that when 16-QAM is used db2 and haar have similar performance but far better than DFT. Fig. 3, where 64-QAM is used haar and db2 performs better than DFT. In Fig.4, DWT-COIFLET wavelet is proposed and compared with different wavelets used before and we can draw DWT-COIFLET yields better performance compare to other wavelets. In Fig 5 Different bandwidths are tested with DWT-COIFLET with respective MSE and SNR. BER can be reduced by using DWT-COIFLET with increased bandwidth and performance of system can ultimately increases with reducing BER.

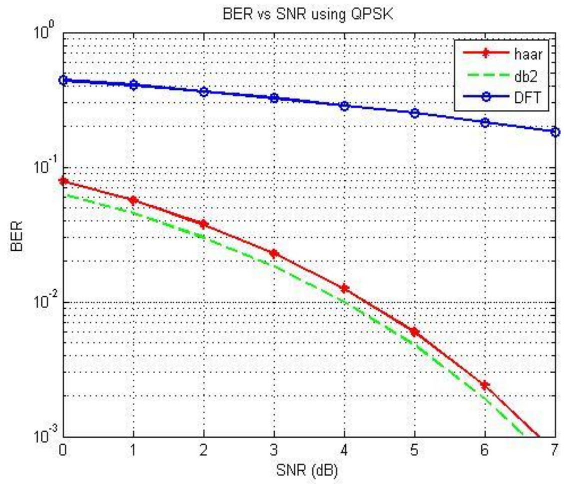

Figure 1: BER vs. SNR using QPSK

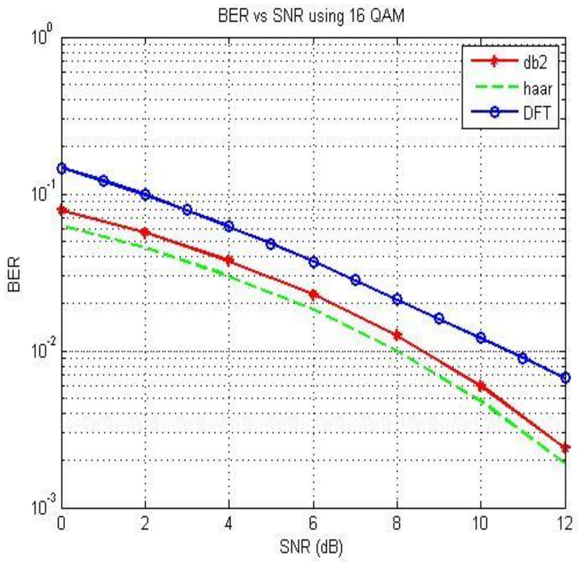

Figure 2: BER vs SNR using 16 QAM

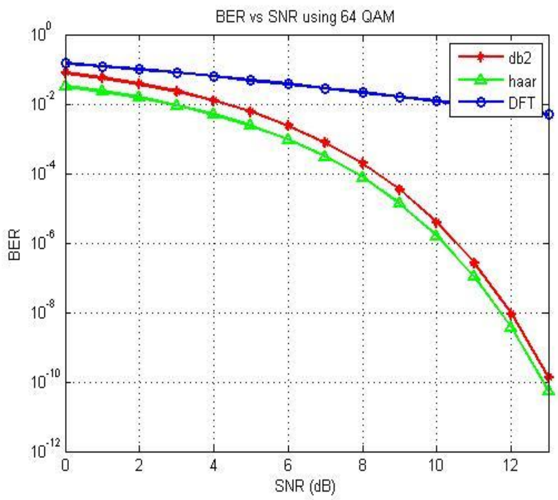

Figure 3: BER vs SNR using 64 QAM

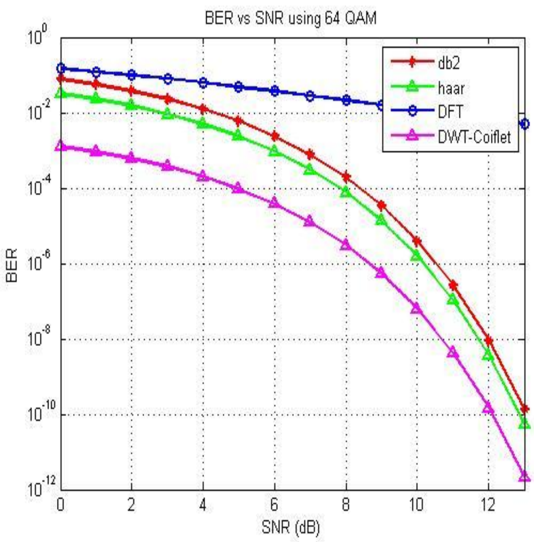

Figure 4: Different wavelets comparison with respective BER vs. SNR using 64QAM

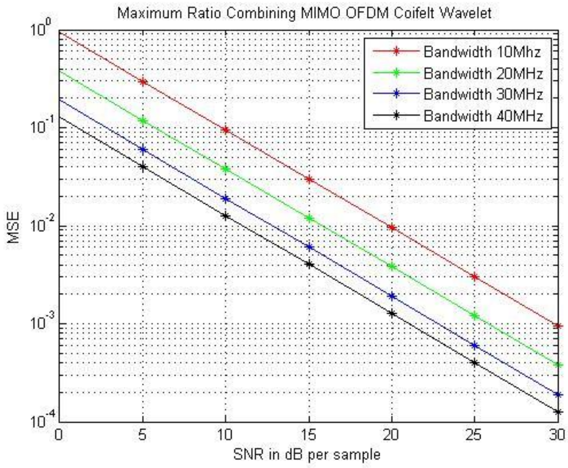

Figure 5: Maximum ratio combining MIMO OFDM Coiflet wavelet

5. Conclusion

Performance of BER is analysed for a design of OFDM coder using different wavelets in LTE. In this we presented a novel algorithm for LTE MIMO scheme based on COIFLET wavelet decomposition, which give better results compared to existing wavelets and we also compare our method with state-of art criteria like DFT and DWT based schemes in AWGN distortion channel and virtual Rayleigh fading channel. 64-QAM is used as modulation technique for COIFLET-DWT based channel evaluation scenario. Finally we can say that BER can be reduced by using DWT-COIFLET wavelet in OFDM coder and also performance can be improved by maximum ratio combining MIMO OFDM.

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